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2,156,358

STABILIZING CIRCUIT

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Fig. 1,

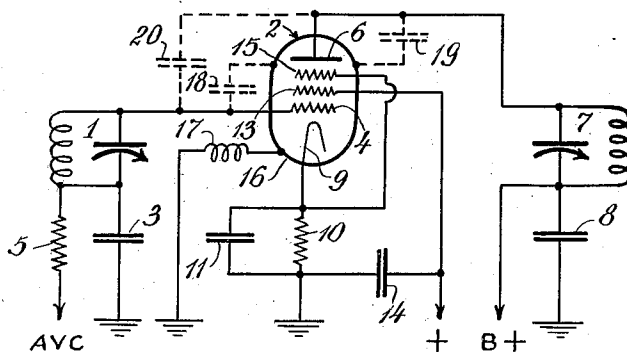


Fig. 2,

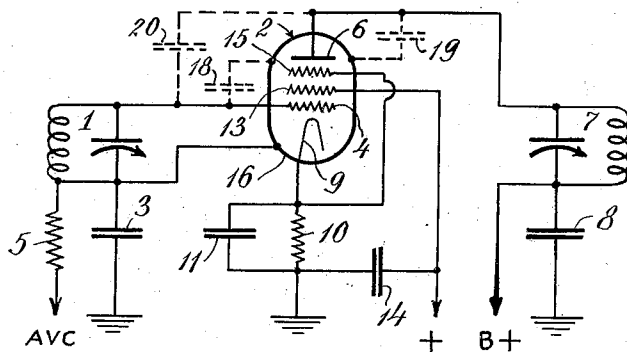
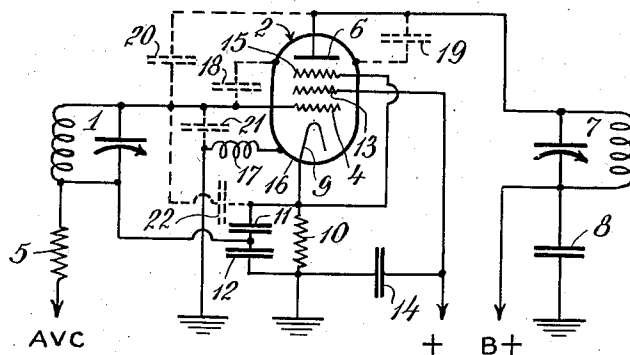


Fig. 3,



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STABILIZING CIRCUIT

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This invention relates to improvements in high-frequency amplifying systems, and more particularly to vacuum-tube amplifiers of the type commonly employed in receivers for modulated high-frequency signals. Although applicable to various types of high-frequency amplifiers, the invention is especially useful in amplifiers intended for operation over a limited range of frequencies, as for example the intermediate-frequency amplifier of a radio receiver of the super-heterodyne type. Such an amplifier is usually initially adjusted for optimum performance at a single fixed frequency, but is designed to pass a relatively narrow band of frequencies lying on either side of its nominal resonant frequency.

In vacuum-tube amplifiers intended for operation at high frequencies, the electrical characteristics of the vacuum tubes themselves introduce several serious problems which must be solved in the design of a satisfactory high-gain amplifier. One of these difficulties is the inherent grid-plate capacitance of the vacuum tube. This capacitance permits a certain amount of feedback from the plate circuit to the grid circuit of the vacuum tube, and, in a high-gain amplifier, this feedback may be sufficient to produce instability and oscillation. Although the effective grid-plate capacitance may be reduced substantially by the use of a screen-grid within the vacuum tube itself, in many cases it is sufficient to introduce serious difficulty in the design of a high-gain amplifier.

Another difficulty is encountered when a self-biasing resistor is inserted between the cathode of the vacuum tube and ground. It is common practice to shunt this resistor with a by-pass capacitor, and this capacitor acts as an impedance which is common to the grid and plate circuits of the vacuum tube with resultant instability of operation. Even the use of a relatively large and expensive capacitor across the cathode resistor is not a positive cure for this source of instability.

An object of this invention is to provide simple and inexpensive means for substantially eliminating the undesirable effects of vacuum-tube grid-plate capacitance in high-gain vacuum-tube amplifiers.

Another object of the invention is to provide means for preventing feedback and instability due to the use of a common impedance in the cathode circuit of a vacuum-tube amplifier.

An additional object of the invention is to provide means for substantially increasing the stable amplification which may be realized in a high-

gain vacuum-tube amplifier without appreciably increasing its cost and complication.

Although the arrangements of the invention are applicable to various types of high-frequency vacuum-tube amplifiers, they are especially useful in intermediate-frequency amplifiers which are designed to have a flat-topped, steep-sided selectivity characteristic, since feedback has a marked tendency to alter the symmetry of the amplifier characteristic and thus introduce serious distortion of the modulated high-frequency signal being amplified. It is a further object of the invention, therefore, to provide a high-frequency amplifier which is capable of being adjusted to have a substantially symmetrical selectivity characteristic of a desired form.

Although the arrangements of the invention are especially suitable for use in an amplifier employing one or more vacuum tubes of the type having a metal outer envelope or shell, it will be understood that tubes of the type having a glass envelope may be employed by providing them with a close-fitting shield of conductive material. Whenever in this specification and the appended claims the term "shell" is used, therefore, it is intended to refer either to the metal outer envelope of the tube itself or to a close-fitting conductive shield surrounding the glass envelope of the tube.

The invention will be better understood by reference to the drawing, in which:

Fig. 1 is the schematic wiring diagram of a vacuum-tube amplifier employing the arrangements of the invention;

Fig. 2 is a modification of the system of Fig. 1; and

Fig. 3 is a second modification of the system of Fig. 1.

Referring to Fig. 1 of the drawing, tuned circuit 1 is in the grid or input circuit of vacuum tube 2. The grid circuit is completed for high-frequency currents by means of capacitor 3, and a direct-current bias voltage is applied to grid 4 through filter resistor 5 from source AVC. The high-frequency plate or output circuit of vacuum tube 2 extends from plate 6 through tuned circuit 7 and capacitor 8 to ground. Cathode 9 of vacuum tube 2 is grounded through resistor 10, which is shunted by capacitor 11. Screen-grid 13 is bypassed to ground by capacitor 14, and suppressor-grid 15 is connected to cathode 9. Shell 16 of vacuum tube 2 is grounded through inductor 17. If vacuum tube 2 is of the glass-envelope type, it will be understood that a close-fitting conduc-

tive shield is to be employed and connected as shown for shell 16.

The capacitance between grid 4 and shell 16 is indicated by dotted capacitor 18, and the capacitance between plate 6 and shell 16 is represented by dotted capacitor 19. The capacitance between grid 4 and plate 6 is depicted by dotted capacitor 20. Reference to capacitors 18, 19 and 20, therefore, is to be taken as meaning the grid-shell, plate-shell, and grid-plate capacitances, respectively, of vacuum tube 2, rather than separate and distinct capacitively reactive circuit components.

In operation, regenerative feedback from the plate circuit to the grid circuit takes place through capacitance 20. If the amplification of vacuum tube 2 is high enough, this regeneration is sufficiently great to produce oscillation. In most cases, there is sufficient regeneration to produce serious instability in high-gain amplifiers. In the arrangements of the present invention illustrated in Figs. 1 and 3, the regeneration is counteracted by regenerative feedback produced by making inductor 17 common to both the grid and the plate circuits.

Capacitance 18 and inductor 17 are effectively in series between grid 4 and ground, and thus some of the current in the input circuit flows through inductor 17. Likewise, capacitance 19 and inductor 17 are effectively in series between plate 6 and ground, causing some of the plate-circuit current to be present in inductor 17. The phase relations between these stray input and output currents is such that there is developed across inductor 17 a voltage which offsets the effect of the regenerative coupling between the input and output circuits due to capacitance 20. By properly choosing the value of inductor 17 for any given type of vacuum tube to be operated at a given frequency, the effects of feedback due to grid-plate capacitance may be substantially eliminated. Thus the operation of a high-gain amplifier may be rendered stable and free from undesired regeneration.

Reference is now made to Fig. 2 of the drawing, in which like components are designated by like reference numerals. Shell 16 of vacuum tube 2 is connected to the junction of capacitor 3 and resistor 5. The value of capacitor 3 is so chosen as to provide shell 16 with the proper potential to balance out the tendency of the grid-plate capacitance 20 to produce feedback and resultant regeneration. The capacitive reactance of capacitor 3 is so small, however, that shell 16 is practically at ground potential and thus fully effective as a shield for vacuum tube 2. The arrangement of Fig. 2 has the advantage of requiring no additional components and of being independent of the frequency at which the amplifier operates.

Capacitor 3 is common to the grid and plate circuits of vacuum tube 2, since the grid circuit is completed to ground through capacitor 3 and one path from plate 6 to ground includes plate-shell capacitance 19 and capacitor 3. By properly choosing capacitor 3, the potential drop across it may be made to substantially cancel the undesired regenerative voltage which is impressed on grid 4 due to grid-plate capacitance 20. Because of the phase shift due to tuned circuit 1, it is possible thus to employ a capacitor as the common circuit element, instead of an inductor as shown in Fig. 1.

Fig. 3 of the drawing shows the system of Fig. 1 to which has been added means for preventing

feedback and instability due to the use of a common impedance in the cathode circuit of the vacuum-tube amplifier. Like components bear like reference numerals. Resistor 10 is shunted by capacitors 11 and 12 in series, and the low-potential terminal of tuned circuit 1 is connected to the junction of capacitors 11 and 12. The capacitance between grid 4 of vacuum tube 2 and ground is indicated by dotted capacitor 21, and the capacitance between grid 4 and cathode 9 of vacuum tube 2 is represented by dotted capacitor 22. The value of capacitance 21 depends both upon the type of vacuum tube employed and the arrangement of components associated with it, and the value of capacitance 22 is determined only by the type of tube.

In practice, the circuit components are so chosen that capacitance 21 is equal to capacitance 22, and that capacitors 11 and 12 are equal to each other. Under these conditions, none of the current in the input or grid circuit of vacuum tube 2 is permitted to flow through cathode resistor 10, so there can be no feedback due to cathode-circuit coupling between grid and plate circuits. Feedback and instability due to capacitance 20 is eliminated in the manner explained in connection with Fig. 1 of the drawing, so that the system is entirely free from either regeneration or degeneration. The arrangements of Fig. 3 are especially advantageous in high-gain amplifiers in which the cathode cannot be by-passed with a large capacitor or grounded, and this embodiment has the feature of requiring minimum additional components. Additionally, the means for preventing feedback due to the common impedance in the cathode circuit is substantially independent of the frequency at which the amplifier operates.

By way of example of one successful embodiment of the arrangements shown in Fig. 3 of the drawing, the following constants are given for a system designed to operate at a frequency of 460 kilocycles per second:

Vacuum tube 1	Type 6K7
Capacitor 8	0.1 microfarad
Resistor 10	300 ohms
Capacitor 11	0.02 microfarad
Capacitor 12	0.02 microfarad
Capacitor 14	0.05 microfarad
Inductor 17	12.0 microhenries

It will be understood that these are approximate values and that the scope of the invention is in no way limited to embodiments employing the same or even closely similar values. A different operating frequency or the use of different types of vacuum tubes may require different values for some of the constants, and such different values are contemplated by the invention.

In some instances, cathode 9 of vacuum tube 2 may be grounded. In this event, the problem of common impedance in the cathode circuit does not arise, and complete stability is obtained as above disclosed in connection with Figs. 1 and 2. The value of inductor 17 is not critical, but in some instances it may be desirable to provide means for adjusting its inductance in order to secure a precise balance of the system.

Although the arrangements of the invention are especially suitable for use in radio receivers, and particularly in the intermediate-frequency portion of superheterodyne radio receivers, it will be understood that they may be employed in radio transmitters and also in other types of high-frequency apparatus in which it is desired to secure

a high degree of efficiency without sacrificing stability. Furthermore, although a pentode vacuum tube is shown in the figures of the drawing, the principles of the invention may be applied to vacuum tubes of any other type to realize a high degree of stable amplification.

Having thus described my invention, what I claim is:

1. A high-frequency amplifier including a vacuum tube having input and output electrodes in proximity and a conductive shell, an input circuit connected between said input electrode and ground, an output circuit connected between said output electrode and ground, and a reactance effectively connected between said shell and ground of such size that feedback from said output circuit to said input circuit due to the proximity of said input and output electrodes is substantially prevented.

2. A high-frequency amplifier including a vacuum tube having input and output electrodes in proximity and a conductive shell, an input circuit connected between said input electrode and ground, an output circuit connected between said output electrode and ground, and an inductive reactance effectively connected between said shell and ground of such size that feedback from said output circuit to said input circuit due to the proximity of said input and output electrodes is substantially prevented.

3. A high-frequency amplifier including a vacuum tube having input and output electrodes in proximity and a conductive shell, an input circuit connected between said input electrode and ground, an output circuit connected between said output electrode and ground, and a capacitive reactance effectively connected between said shell and ground of such size that feedback from said output circuit to said input circuit due to the proximity of said input and output electrodes is substantially prevented.

4. A high-frequency amplifier including a vacuum tube having input and output electrodes in proximity and a conductive shell, an input circuit connected between said input electrode and ground and including a first resonant circuit tuned to a predetermined frequency, an output circuit connected between said output electrode and ground and including a second resonant circuit tuned to said frequency, and a reactance ef-

fectively connected between said shell and ground of such size that feedback from said output circuit to said input circuit at said frequency due to the proximity of said input and output electrodes is substantially prevented.

5. A high-frequency amplifier including a vacuum tube having input and output electrodes in proximity and a conductive shell, an input circuit connected between said input electrode and ground and including a first resonant circuit tuned to a predetermined frequency, an output circuit connected between said output electrode and ground and including a second resonant circuit tuned to said frequency, and an inductive reactance effectively connected between said shell and ground of such size that feedback from said output circuit to said input circuit at said frequency due to the proximity of said input and output electrodes is substantially prevented.

6. A high-frequency amplifier including a vacuum tube having input and output electrodes in proximity and a conductive shell, an input circuit connected between said input electrode and ground and including a first resonant circuit tuned to a predetermined frequency, an output circuit connected between said output electrode and ground and including a second resonant circuit tuned to said frequency, and a capacitive reactance effectively connected between said shell and ground of such size that feedback from said output circuit to said input circuit at said frequency due to the proximity of said input and output electrodes is substantially prevented.

7. A high-frequency amplifier including a vacuum tube having input and output electrodes in proximity, a cathode and a conductive shell, an impedance including a resistor shunted by two capacitors in series connected between said cathode and ground, an input circuit connected between said input electrode and the junction of said capacitors, an output circuit connected between said output electrode and ground, and an inductive reactance connected between said shell and ground, said capacitors and said inductive reactance being of such sizes that instability due to the proximity of said input and output electrodes and degeneration due to said impedance are substantially prevented.

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